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Bassani et al.

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(54) **TORQUE MEASURING ASSEMBLY SUITABLE FOR USE IN A CONTAINER CAPPING MACHINE**

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B67B 3/20 (2006.01)
B67B 3/26 (2006.01)
G01L 5/24 (2006.01)

(52) **U.S. Cl.**
USPC **53/490**; 53/53; 53/75; 53/331.5; 73/862.21; 73/862.23

(58) **Field of Classification Search**
CPC B67B 3/261; G01L 5/0042; B65B 7/2835
USPC 53/396, 490, 53, 75, 76, 317, 331.5; 73/862.21, 862.23, 862.27, 862.325, 73/862.338
IPC B67B 3/20, 3/26
See application file for complete search history.

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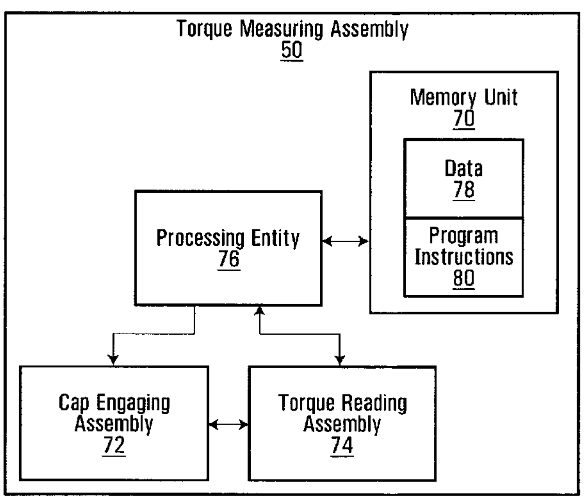
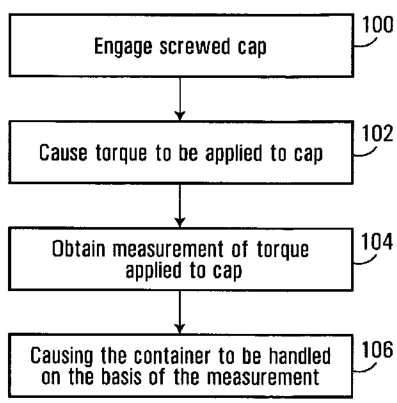
(57) **ABSTRACT**

The present invention provides a torque measuring station, comprising a cap-engaging assembly for engaging a cap that has been secured onto a container, a torque measuring assembly for obtaining a measurement indicative of the torque exerted on the cap by the cap engaging assembly and a processing entity in communication with the torque measuring assembly. The processing entity is operative for receiving the measurement indicative of the torque, and for causing the container to be handled, once released from said cap-engaging assembly, on the basis of the measurement indicative of the torque applied to the cap.

26 Claims, 10 Drawing Sheets





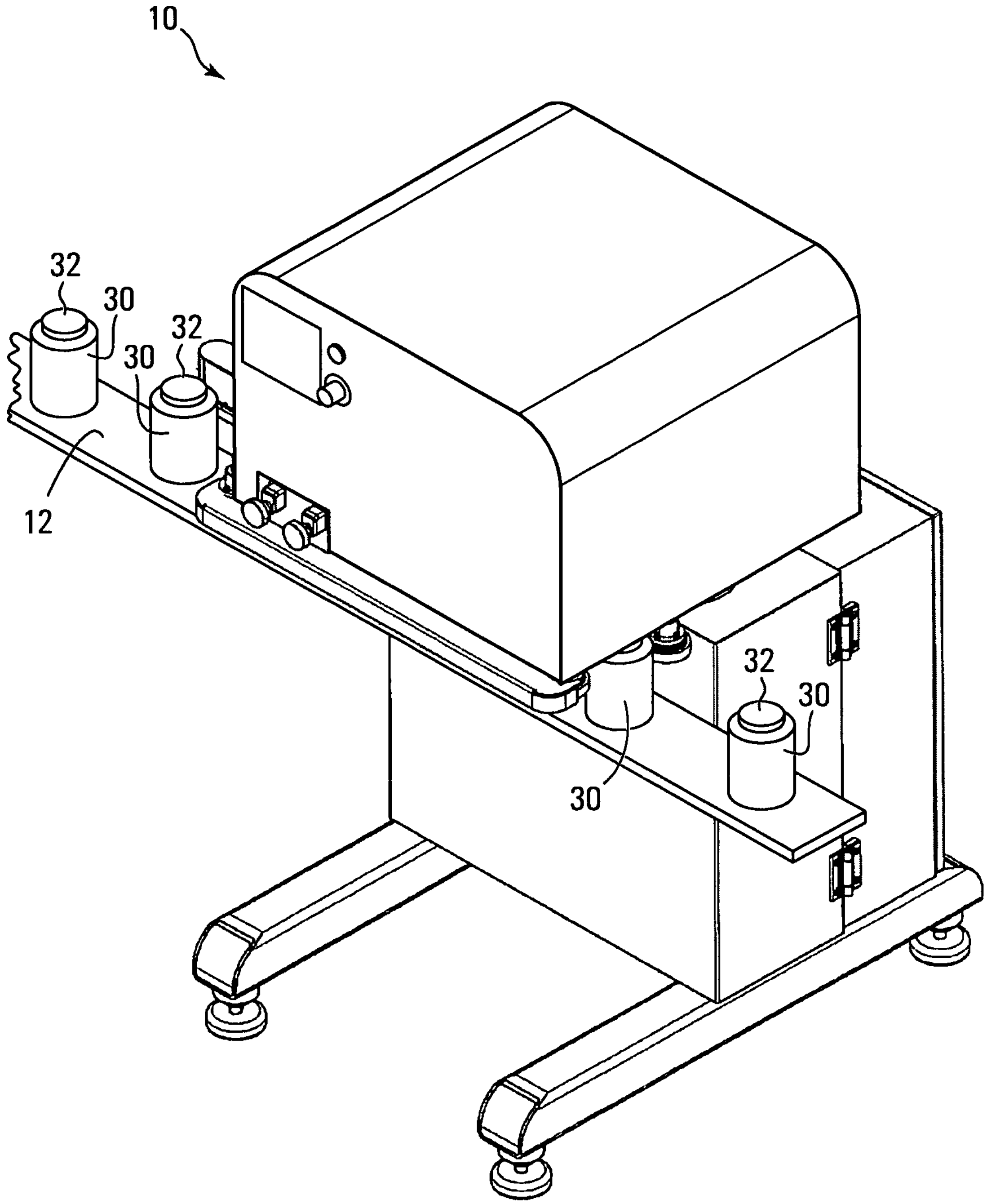
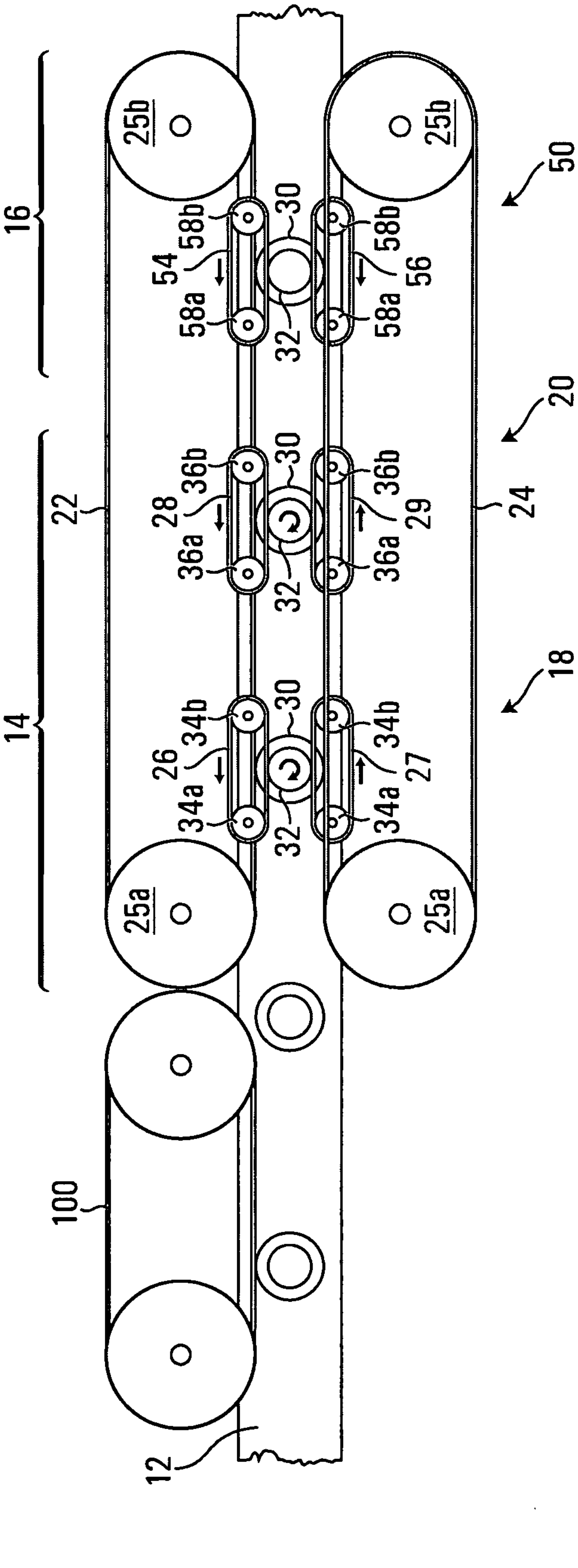


FIG. 1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14
22
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25b
25a
100
12
50
20
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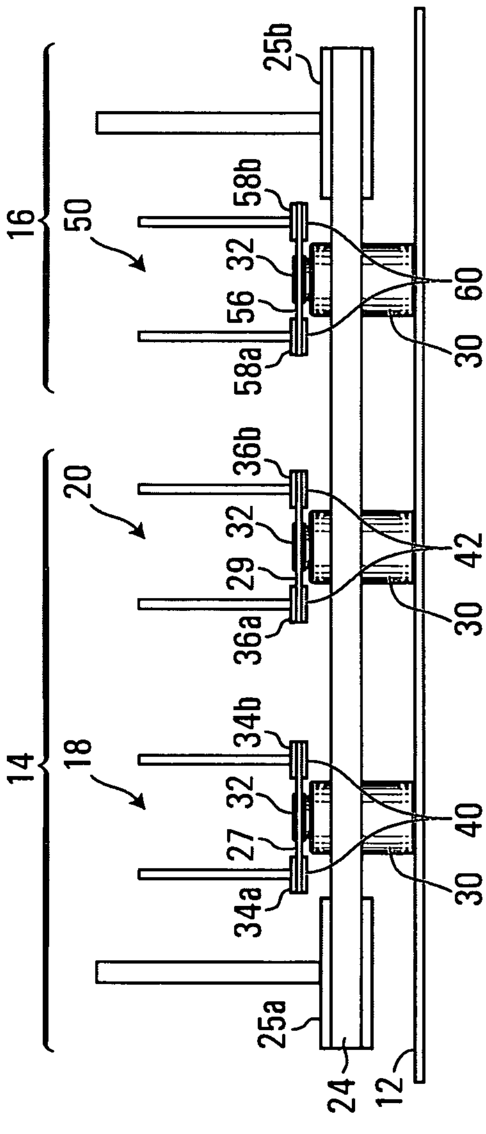
58b
30
32
28
29
26
27
36a
36b
34a
34b

FIG. 2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20
29
32
36a
36b
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25b
24
12

FIG. 3

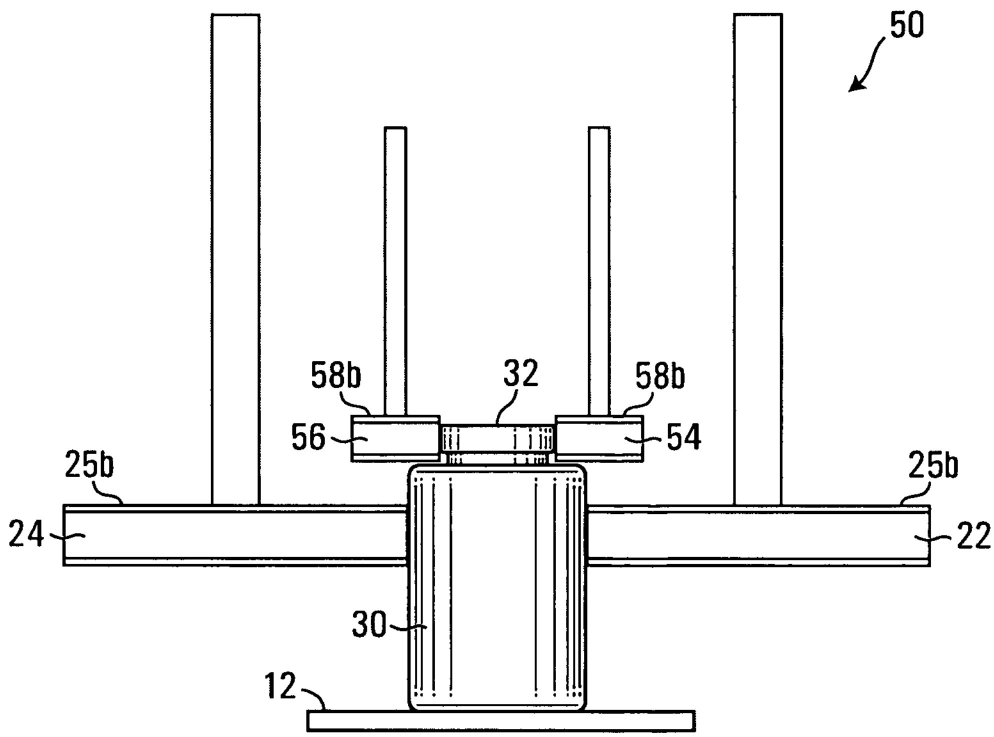


FIG. 4

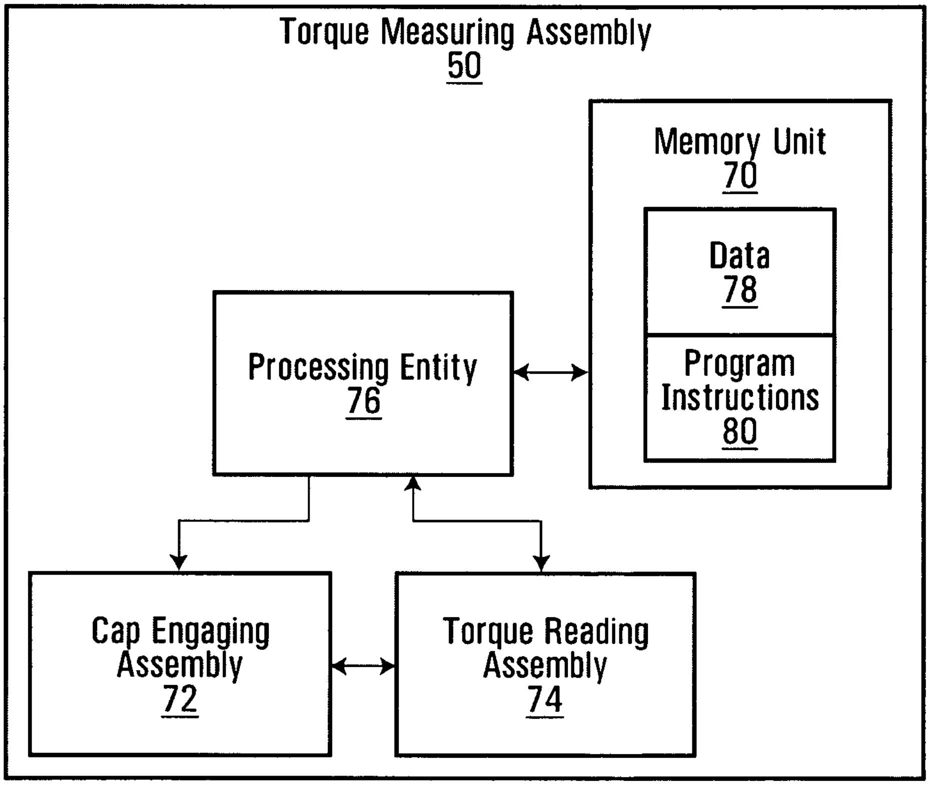

Torque Measuring Assembly
50
Memory Unit
70
Data
78
Program Instructions
80
Processing Entity
76
Cap Engaging Assembly
72
Torque Reading Assembly
74

FIG. 5

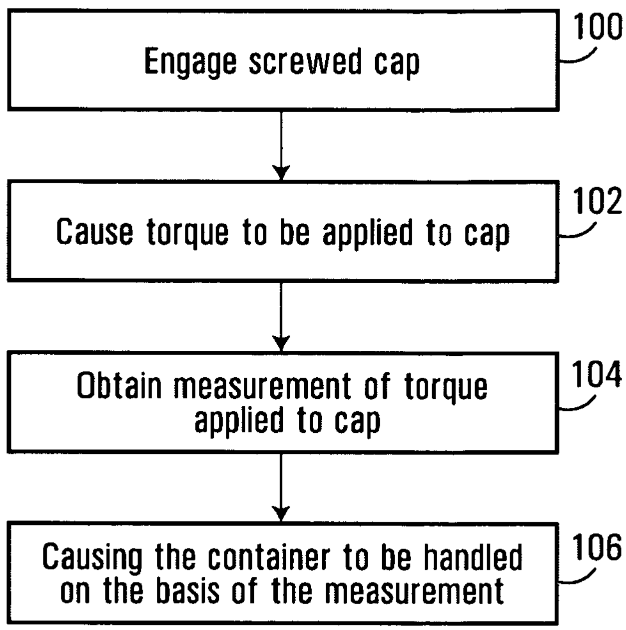
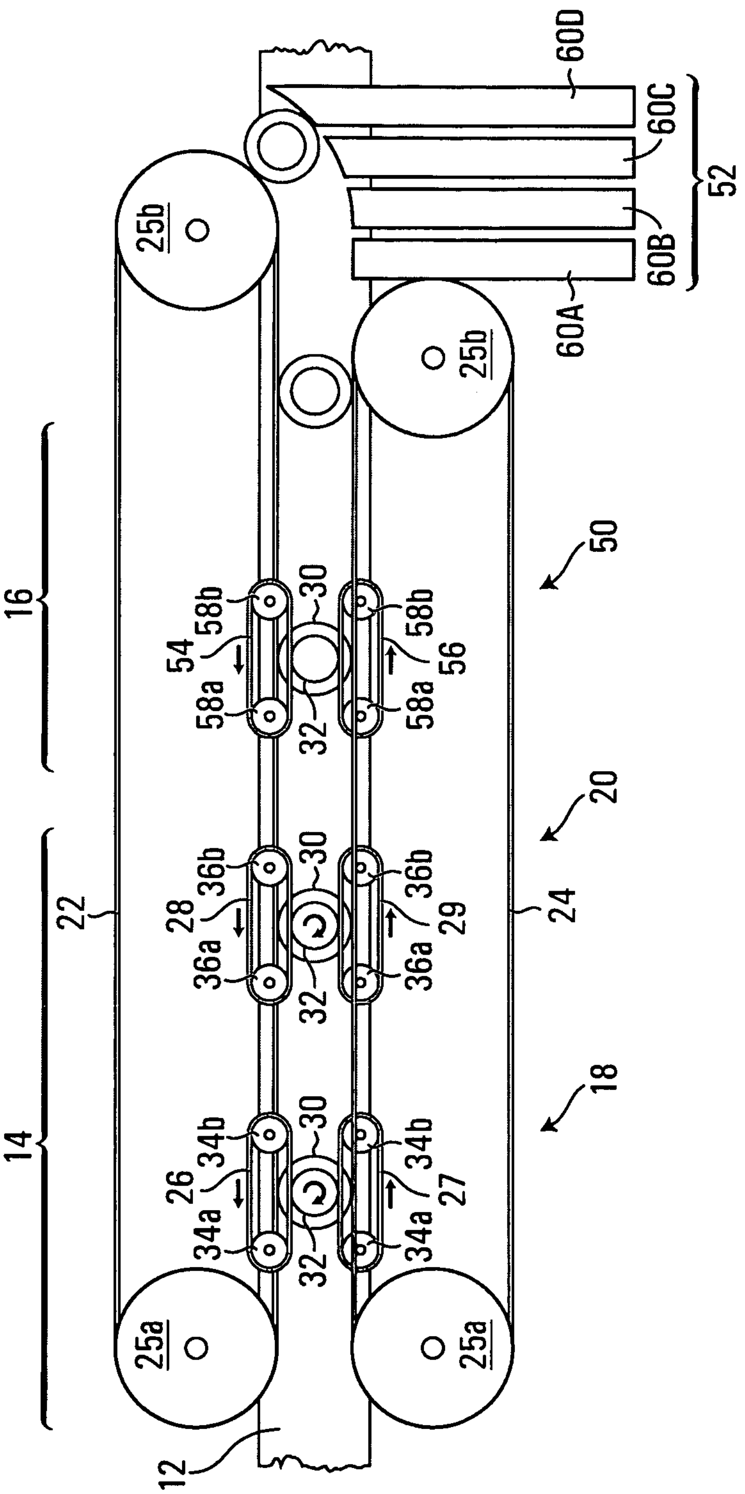

Engage screwed cap
100
Cause torque to be applied to cap
102
Obtain measurement of torque applied to cap
104
Causing the container to be handled on the basis of the measurement
106

FIG. 6



60D
60C
52
60B
60A
25b
25b
16
54
58b
58a
30
32
56
50
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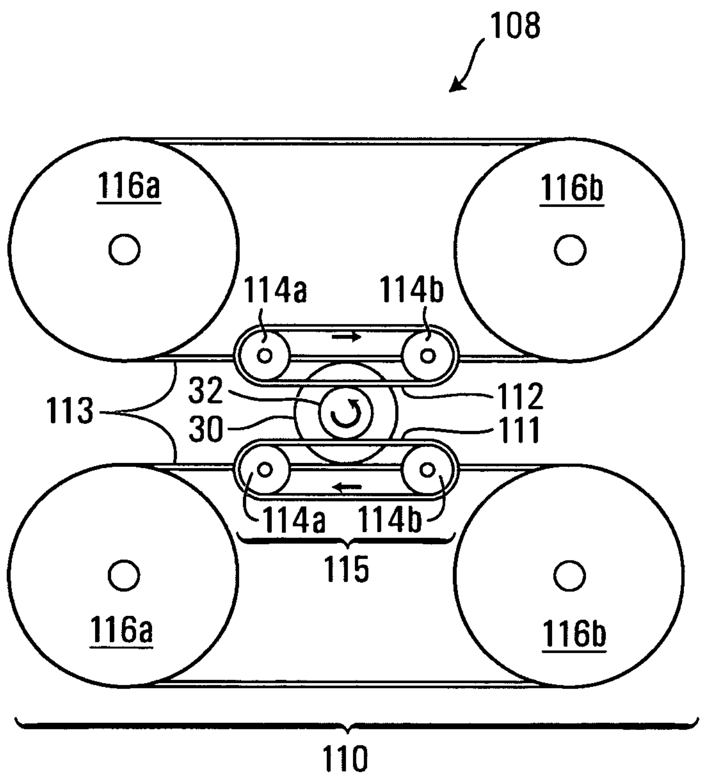
18
25a
25a
12

FIG. 7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114b
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112
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114a
114b
115
116a
116b
110

FIG. 8

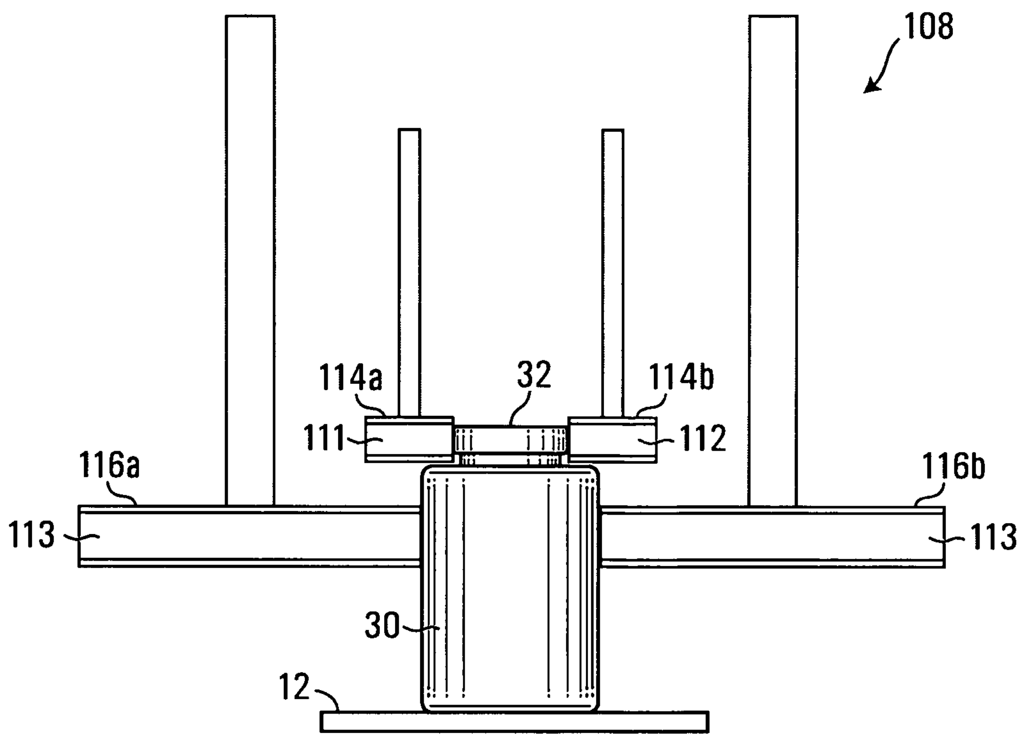

FIG. 9

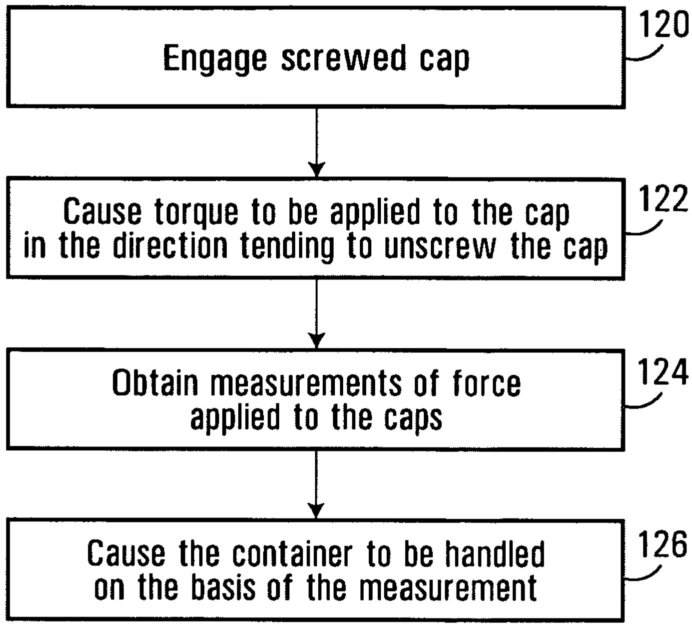
Engage screwed cap
120
Cause torque to be applied to the cap in the direction tending to unscrew the cap
122
Obtain measurements of force applied to the caps
124
Cause the container to be handled on the basis of the measurement
126

FIG. 10

TORQUE MEASURING ASSEMBLY SUITABLE FOR USE IN A CONTAINER CAPPING MACHINE

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims the benefit under 35 USC 119(e) of U.S. Provisional Patent Application 61/112,511 filed on Nov. 7, 2008 and hereby incorporated by reference herein.

FIELD OF THE INVENTION

The present invention relates to torque measuring assemblies, and specifically to torque measuring assemblies suitable for ensuring that an acceptable amount of torque has been applied to a cap that has been secured to a container.

BACKGROUND OF THE INVENTION

Container capping machines for rotating caps onto containers are known in the art. Typically, container capping machines use discs or belts for rotating the caps in relation to the containers such that the caps are screwed onto the necks of the containers. In this manner, caps that have been loosely placed onto the necks of containers are rotated until they are tightly secured to the container.

In many industries, such as in the pharmaceutical industry, it is important that the caps are screwed onto the containers tightly, so as to prevent unwanted opening of the container which could lead to tampering or contamination of the contents of the containers. As such, there are requirements surrounding the minimum amount of torque that should be applied to the caps, in order to ensure that the caps are securely tightened onto the containers. In order to comply with these requirements, container capping machines must ensure that they apply at least the minimum required amount of torque to the caps. If the cap is not screwed onto the container tightly enough, then the container does not meet the imposed requirements and the container needs to be removed from the production line.

In light of this minimum torque requirement, it is common for container capping machines to include load cells that are in communication with the capping disks and/or belts for measuring the amount of torque that is applied to the caps as they are being secured onto the containers. An example of this type of arrangement is described in U.S. Pat. No. 7,325,369 to Luc Jalbert. However, a deficiency with this type of arrangement is that the load cell is coupled directly to the brake of one of the tightening belts. As such, if the capping arrangement is defective for any reason, the load cell will provide a faulty reading which could lead to caps that do not meet the minimum torque requirement being kept in the production line, and eventually making their way into consumer's hands.

In light of the above, there is a need in the industry for an improved container capping machine that alleviates, at least in part, the deficiencies of existing container capping machines.

SUMMARY OF THE INVENTION

In accordance with a first broad aspect, the present invention provides a torque measuring station, comprising a cap-engaging assembly for engaging a cap that has been secured onto a container, a torque measuring assembly for obtaining a measurement indicative of the torque exerted on the cap by the cap engaging assembly and a processing entity in communication with the torque measuring assembly. The processing entity is operative for receiving the measurement indicative of the torque, and for causing the container to be handled, once released from said torque measuring station, on the basis of the measurement indicative of the torque applied to the cap.

In accordance with a second broad aspect, the present invention provides a method comprising engaging, at a cap-engaging assembly, a cap that has been secured onto a container, applying, via the cap-engaging assembly, a torque to the cap and obtaining a measurement indicative of the torque applied to the cap by the cap-engaging assembly. The method further comprises causing the container to be handled, once released from the cap-engaging assembly, on the basis of the measurement indicative of the torque applied to the cap.

In accordance with a third broad aspect, the present invention provides a torque measuring station. The torque measuring station comprises a cap-engaging assembly for sequentially engaging caps that have been secured onto respective containers, a torque measuring assembly operative for obtaining measurements indicative of the torque exerted on each of the sequentially engaged caps by the cap engaging assembly and a processing entity in communication with the torque measuring assembly for receiving the measurements indicative of the torque applied to each of the sequentially engaged caps. The processing entity is further operative for generating statistical data, at least in part on the basis of the measurements of the torque applied to each of the sequentially engaged caps.

In accordance with a fourth broad aspect, the present invention provides a container capping system, comprising a cap applying station operative for engaging a cap positioned on a container for applying a torque to the cap for securing the cap onto the container. The container capping system further comprising a torque measuring station located subsequent to the cap applying station. The torque measuring station being operative for engaging the cap for applying a torque to the cap in a direction tending to unscrew the cap from the container. The torque measuring station being operative for determining whether the cap reaches a predetermined torque value before starting to unscrew from the container.

In accordance with a fifth broad aspect, the present invention provides a container capping machine that comprises at least one container gripping belt for supporting a container moving through the container capping machine, at least one pair of cap engaging belts for applying a torque to a cap that has been placed on the container and at least one in-feed belt positioned prior to the at least one container gripping belt. The at least one in-feed belt is operative for supplying containers to the at least one container gripping belt. The container capping machine further comprises a processing entity for controlling the at least one in-feed belt independently of the at least one container gripping belt such that the at least one in-feed belt is activated and deactivated independently of the at least one container gripping belt.

In accordance with a fifth broad aspect, the present invention provides a method for controlling a supply of containers to a container capping machine. The container capping machine comprises at least one container gripping device for guiding a container through the container capping machine, and at least one in-feed device positioned prior to the at least one container gripping device for supplying containers to the at least one container gripping device. When the at least one container gripping device and the at least one in-feed device are in activation, the method comprises causing the at least one in-feed device to be de-activated such that the at least one in-feed device is no longer able to supply containers to the at least one container gripping device, maintaining the at least one container gripping device in activation at least until the containers that are being guided through the container capping machine by the at least one container gripping device have exited the container capping machine such that they are no longer being guided by the at least one container gripping device and causing the at least one container gripping device to be de-activated.

In accordance with a sixth broad aspect, the present invention provides a container capping machine. The container capping machine comprises a cap-engaging station for securing a cap onto a container, a torque measuring station for determining if the cap has been secured onto the container to at least a minimum required torque value and a rejection device in communication with the torque measuring station. The rejection device being operative for removing a container from continued travel along a production line, upon determination that the cap has not been secured onto the container to at least the minimum required torque value.

BRIEF DESCRIPTION OF THE DRAWINGS

In the accompanying drawings:

FIG. **1** shows a front perspective view of a container capping machine in accordance with a non-limiting embodiment of the present invention;

FIG. **2** shows a top representational view of a cap screwing station and torque measuring station in accordance with a non-limiting embodiment of the present invention;

FIG. **3** shows a side representational view of the cap screwing station and torque measuring station of FIG. **3**;

FIG. **4** shows a front representational view of a torque measuring assembly in accordance with a non-limiting embodiment of the present invention;

FIG. **5** shows a non-limiting functional block diagram of a torque measuring assembly in accordance with the present invention;

FIG. **6** shows a non-limiting flow diagram of a process performed by the torque measuring assembly of the present invention;

FIG. **7** shows a non-limiting alternative top representational view of a cap screwing station and torque measuring station in accordance with a non-limiting embodiment of the present invention;

FIG. **8** shows a top representational view of a torque measuring assembly in accordance with a second non-limiting embodiment of the present invention;

FIG. **9** shows a side representational view of the torque measuring assembly of FIG. **7**; and

FIG. **10** shows a non-limiting flow diagram of a process performed by the torque measuring assembly of FIG. **7**.

Other aspects and features of the present invention will become apparent to those ordinarily skilled in the art upon review of the following description of specific embodiments of the invention in conjunction with the accompanying figures.

DETAILED DESCRIPTION

Shown in FIG. **1** is a container capping machine **10** that is suitable for use in container filling assembly lines for securing caps **32** onto filled containers **30**. The container capping machine **10** is operative for rotating caps **32** in relation to their respective containers **30**, such that the caps **32** are securely screwed onto the necks of the containers **30**.

During operation, the containers **30** travel through the container capping machine **10** along a predetermined path. In the embodiment shown, the containers travel through the container capping machine **10** along a path **12** at a suitable speed for allowing the container capping machine **10** to screw the caps **32** onto the necks of the containers **30**. In accordance with a first non-limiting embodiment, the path **12** may be a stationary path, such that the containers **30** are carried along the path via container gripping belts that will be described in more detail below. In this manner, the containers **30** simply slide along the path **12**. Alternatively, the path **12** may be a conveyor belt, a sliding rail, or any other transportation mechanism for moving the containers **30** through the container capping machine **10**.

When containers **30** enter the container capping machine **10** they are passed through a cap pick up station to pick up the caps **32**. The placing of caps **32** on the containers **30** is known in the art, and as such will not be described in more detail herein.

In accordance with the present invention, and as shown in FIGS. **2** and **3**, the container capping machine **10** includes a cap applying station **14** and a torque measuring station **16**. The cap applying station **14** includes a cap applying assembly **18** and a cap torquing assembly **20**. The cap applying assembly **18** is operative for rotating the caps **32** in relation to their respective containers **30**, so as to pre-screw the loose caps **32** onto their respective containers **30**. The cap torquing assembly **20** is operative for applying a predetermined torque to the caps **32** for tightening the caps **32** securely onto their respective containers **30**. An advantage of having a separate cap applying assembly **18** and cap torquing assembly **20**, is that the length of each assembly **18** and **20** can be shorter than one long cap screwing assembly that does both the screwing and the torquing. This enables the container capping machine **10** to handle containers **30** that are positioned more closely together. In this manner, the container capping machine **10** is able to process more containers **30** within a given period of time.

Although the cap applying assembly **18** and the cap torquing assembly **20** are described herein as being separate, in an alternative embodiment, the container capping machine **10** may include only one capping assembly that is able to both screw the caps onto the containers, and provide enough torque to adequately secure the caps onto their respective containers.

As shown in FIGS. **2** and **3**, the cap applying assembly **18** and the cap torquing assembly **20** include two container gripping belts **22** and **24**. The container gripping belts **22** and **24** are operative for receiving the containers **30**, and for transporting and stabilizing the containers **30** as they move through the container capping machine **10**. In the embodiment shown, the two container gripping belts **22** and **24** are shown positioned opposite each other at a predetermined distance for receiving and gripping the containers **30**. In a non-limiting embodiment of the present invention, the distance separating the two opposing container gripping belts **22** and **24** can be adjusted such that the container capping machine **10** can accommodate containers **30** of different sizes and shapes. As such, the belts **22** and **24** can be moved closer together or further apart depending on the size of the container **30** being handled.

Each of the two belts **22** and **24** is positioned around a pair of pulleys **25***a* and **25***b*. At least one of the pulleys **25***a* and **25***b* is driven by a motor (not shown) for causing the belts **22** and **24** to rotate. Each of the two belts **22** and **24** is caused to rotate at substantially the same speed, with one belt moving in a counter clock-wise direction, and the other belt moving in a clock-wise direction, such that the rotation of the two belts **22** and **24** does not cause the container **30** to spin while it is being gripped by the belts **22**.

The cap applying assembly **18** further includes a pair of cap engaging belts **26** and **27** and the cap torquing assembly **20** further includes a pair of cap engaging belts **28** and **29**. In the embodiment shown, the two cap engaging belts **26** and **27** and the two cap engaging belts **28** and **29** are shown positioned opposite each other at a predetermined distance. In a non-limiting embodiment of the present invention, the distance separating the two opposing belts **26** and **27**, and the distance separating the two opposing belts **28** and **29** can be adjusted such that they can accommodate caps **32** of different sizes and shapes. As such, the belts **26** and **27**, and **28** and **29** can be moved closer together or further apart depending on the size of the caps **32** being tightened. It should be appreciated that the position of the cap engaging belts **26** and **27**, and **28** and **29** can be adjusted independently of the position of the container gripping belts **22** and **24**.

With respect to the cap applying assembly **18**, the pair of cap engaging belts **26** and **27** are each positioned around two pulleys **34***a* and **34***b*. At least one of these pulleys **34***a* or **34***b* is driven by a motor (not shown) for causing the belts **26** and **27** to rotate. In the embodiment shown in FIG. **2**, the containers **30** are moving in a direction from left to right, and the two belts **26** and **27** both rotate in a counter-clockwise direction. As such, when the caps **32** are engaged by the two belts **26** and **27**, the belts **26** and **27** apply a tangential force to the caps that cause the caps **32** to spin clockwise in relation to the container **30**, which causes the caps **32** to be screwed onto the containers **30**. In addition, in order to screw the caps **32** onto the containers **30** quite quickly, the cap engaging belts **26** and **27** rotate at a faster rate than the container gripping belts **22** and **24**. For example, the cap engaging belts **26** and **27** may rotate at twice the speed of the container gripping belts **22** and **24**. The speed at which the cap engaging belts **26** and **27** rotate will be determined by an operator of the machine on the basis of the size of the caps **32** and the amount of spin or torque desired to be applied to the caps **32**, among other possibilities.

Each of the belts **26** and **27** includes a cap engaging region **40** (shown in FIG. **3**) that is the region that engages the caps **32**. As mentioned above, the cap applying assembly **18** is operative for pre-screwing the caps **32** onto the containers **30**, which means that this cap applying assembly **18** does not tightly screw the caps **32** onto the containers. In order to prevent the caps **32** from being screwed onto the containers **30** too tightly, various different factors can be controlled, such as the speed at which the cap engaging belts **26** rotate, and the torque applied by the belts **26** and **27** to the cap. For example, in certain non-limiting embodiments, the driven pulley, which for the sake of example will be driven pulley **34***b*, may be connected to a mechanical or electrical clutch that slips when a predetermined level of torque has been applied to the cap **32**.

With respect to the cap torquing assembly **20**, the pair of cap engaging belts **28** and **29** are positioned around pulleys **36***a* and **36***b*. At least one of these pulleys **36***a* or **36***b* is driven by a motor (not shown) for causing the belts **28** to rotate. In the embodiment shown, the two belts **28** and **29** both rotate in a counter-clockwise direction for causing the caps **32** to spin clockwise in relation to the container **30**. This causes the caps **32** to be further screwed onto the containers **30** for tightening the caps **32** onto the containers **30**. The cap engaging belts **28** and **29** are operative for rotating at a faster speed than the container gripping belts **22** and **24**.

Each of the cap-engaging belts **28** and **29** includes a cap engaging region **42** (shown in FIG. **3**) that is the region that engages the cap **32**. As mentioned above, the cap torquing assembly **20** is operative for causing the caps **32** to be tightly secured onto the containers **30** to at least a minimum torque level. As such, it is the job of the cap torquing assembly **20** to tighten the caps **32** securely onto the containers **30**. The speed of rotation of the belts **28** and **29** and the amount of force that can be applied to the caps **32**, can be selected and calibrated such that at least a minimum torque level is applied to the caps **32**. In accordance with a non-limiting embodiment, the driven pulleys, which for the sake of example will be pulleys **36***b*, may be connected to an electrical or mechanical torque limiting device, for determining when the predetermined amount of torque has been applied. For example, a mechanical or electrical clutch that is connected to the driven pulleys **36***b* may slip, such that no further torque is applied to the caps **32**.

Once the containers **30** exit the cap applying station **14**, the caps **32** should have been tightened onto the containers to within a pre-determined torque range, such that they have been tightened to at least a minimum required torque value. For safety and verification purposes, the container capping machine **10** of the present invention further includes the torque measuring station **16** that is able to ensure that the caps **32** applied to the container by the container capping station **14** meet a minimum required torque value. In this manner, and as will be described below, the torque measuring station **16** provides a separate, independent assembly for verifying the level of torque that has been applied to each one of the caps **32**.

In accordance with a non-limiting embodiment, and as shown in FIG. **2**, the container capping machine **10** includes an independent in-feed belt **100** that is positioned prior to the container gripping belts **22** and **24**. The in-feed belt **100** is operative for supplying the containers **30** to the container gripping belts **22** and **24**. The in-feed belt **100** is connected to an independent motor, such that the activation, deactivation and speed of rotation of the in-feed belt **100** can be controlled independently from the activation, deactivation and speed of rotation of the container gripping belts **22** and **24** of the container capping machine **10**.

In previous container capping machines, when it was necessary to shut down the machine, there would still be containers **30** and caps **32** engaged by the container gripping belts and the cap engaging belts. This meant that abnormal forces would be applied to the caps **32** and/or containers **30** while the container capping machine **10** was being shut down, or started up. This could result in the containers **30** tipping over and jamming the machine, or the caps being applied such that they are too tight, too loose or misaligned on the containers **30**. As such, the caps **32** that were applied to containers **30** during the start-up and shut-down operations, would not be screwed onto the containers **30** to the appropriate torque level and would have to be discarded.

In accordance with the present invention, in order to avoid having containers **30** and caps **32** positioned within the container gripping belts **22** and **24** and the cap engaging belts **26**, **27**, **28** and **29** at the time of shut-down (and start up), the in-feed belt **100** can be deactivated prior to shutting down the container gripping belts **22** and **24**, such that the supply of containers **30** to the container gripping belts **22** and **24** stops. In this way, the in-feed belt **100** will prevent further containers **30** and caps **32** from entering the container capping machine **10**. Once all the containers **30** and caps **32** that are being processed by the container gripping belts **22** and **24** and the cap engaging belts **26**, **27**, **28** and **29** have left the container capping machine **10**, the container gripping belts **22** and **24** and the cap engaging belts **26**, **27**, **28** and **29** can then be shut down. Likewise, in the case of start up, the in-feed belt **100** is not activated until the container capping machine **10** has been initiated such that the container gripping belts **22** and **24**, and the cap engaging belts **26**, **27**, **28** and **29** are functioning at a steady state. At that point, the in-feed belt **100** can be activated so as to start supplying containers **30** to the container gripping belts **22** and **24**.

In addition to controlling the supply of containers **30** to the container gripping belts **22** and **24**, the in-feed belt **100** can also regulate the speed at which the containers **30** are supplied to the container gripping belts **22** and **24**. More specifically, by adjusting the speed of the in-feed belt **100**, the rate at which containers **30** are supplied to the container gripping belts **22** and **24** can be controlled.

In accordance with a non-limiting embodiment, the in-feed belt **100** is controlled by a processing entity (such as processing entity **76** shown in FIG. **5**) that is in communication with a motor (not shown) for causing the in-feed belt **100** to rotate. As mentioned above, the motor that causes the in-feed belt **100** to rotate is independent from the motor that causes the container gripping belts **22** and **24** to rotate, such that rotation of the in-feed belt **100** can be controlled independently from the rotation of the container gripping belts **22** and **24**.

The processing entity that controls the motor for the in-feed belt **100** can be the same processing entity that controls the motor for the container gripping belts **22** and **24**, and the cap engaging belts **26**, **27**, **28** and **29**. Alternatively, the processing entity that controls the motor for the in-feed belt **100** can be dedicated to controlling the motor for the in-feed belt **100**. In such a case, the processing entity that controls the motor of the in-feed belt **100** will be in communication with one or more processing entities that control the motors for the container gripping belts **22** and **24**. In this manner, the processing entities that control the in-feed belt and the container gripping belts **22** and **24** can coordinate the operation of the in-feed belt **100** and the container gripping belts **22** and **24**. In either case, the processing entity that is operative for controlling the activation and deactivation of the in-feed belt **100**, is operative for doing so independently of the activation and deactivation of the container gripping belts **22** and **24**. As such, the activation or deactivation of the in-feed belt **100** does not need to be done simultaneously with the activation or deactivation of the container gripping belts **22** and **24**. In this manner, the in-feed belt **100** can be deactivated prior to the deactivation of the container gripping belts **22** and **24**, and can be re-activated following the activation of the container gripping belts **22** and **24**.

It should be appreciated that the in-feed belt **100** can also prevent supply of containers **30** to the container gripping belts during change over, during testing, and/or during troubleshooting.

The torque measuring station **16** will now be described in more detail with respect to FIGS. **2** and **3**. As shown, the torque measuring station **16** includes a torque measuring assembly **50**. In the embodiment shown, the container gripping belts **22** and **24**, as described with respect to the cap applying station **14**, continue to carry and/or support the containers **30** through the torque measuring assembly **50**. It should be appreciated that in an alternative embodiment, the torque measuring station **16** may comprise separate container gripping belts.

The torque measuring assembly **50** includes a pair of cap engaging belts **54** and **56**. The cap engaging belts **54** and **56** are positioned opposite each other, with a predetermined distance therebetween. The distance separating the cap engaging belts **54** and **56** can be adjusted so as to be able to accommodate caps **32** of different shapes and/or sizes. The position of the cap engaging belts **54** and **56** can be adjusted independently of the position of the container gripping belts **22** and **24**. As such the cap engaging belts **54** and **56** can be moved closer together or farther apart depending on the size of the containers **30** and caps **32** being handled. Mechanisms and mounting arrangements for allowing the distance separating the belts **54** and **56** to be adjusted are known in the art, and as such will not be described in more detail herein.

Each of the cap engaging belts **54** and **56** is positioned around two pulleys **58***a* and **58***b*. At least one of these pulleys **58***a* and **58***b* is driven by a motor (not shown) for causing the belts **54** and **56** to rotate. For the purposes of the present description, the pulleys **58***b* will be described as being the driven pulleys, however, it should be appreciated that the pulleys **58***a* (or both pulleys **58***a* and **58***b*) could be the driven pulleys. During operation, the pulleys **58***a* and **58***b* cause the cap engaging belts **54** and **56** to rotate. More specifically, belt **54** rotates in a counter clockwise direction, and belt **56** rotates in a clockwise direction at a lower speed then belt **54**, thus causing a tangential over-torquing force to be applied to the caps **32**.

More specifically, belt **56** rotates in the clockwise direction at only a slightly lower speed than belt **54**, such that no slippage occurs. The rotation of these two cap engaging belts **54** and **56** is such that a small amount of torque is applied to the caps **32**.

In accordance with the present invention, a load cell, or other force reading mechanism known in the art, is in communication with the driven pulleys **58***b* for measuring the force that is applied to the caps **32** by the cap engaging belts **54** and **56**. In an alternative embodiment, a load cell is in communication only with the driven pulley **58***b* of belt **56**. Given that the caps **32** have already been tightened onto the containers **30** by the time they enter the torque measuring station **16**, the tangential force applied to the caps **32** by the belts **54** and **56** should not cause the caps **32** to be tightened significantly more onto the containers **30**.

Each of the cap-engaging belts **54** and **56** includes a cap engaging region **60** (shown in FIG. **3**) which is the region of the cap-engaging belts **54** and **56** that engages the cap **32**. As mentioned above, the purpose of the cap engaging belts **54** and **56** of the torque measuring assembly **50** is to apply a force to the caps **32**, which can be measured so as to be able to determine whether each cap **32** has been screwed onto a respective container **30** to a minimum required torque value. In operation, as a cap **32** is engaged by the belts **54** and **56** in the cap engaging region **60**, the belts **54** and **56** exert a tangential force against the cap **32**, which thus applies a torque to the cap. Given that the cap **32** has already been screwed onto its container **30**, to presumably a minimum required torque value, the cap **32** will apply a resistance against the rotation of the belts **54** and **56**. While the cap **32** is traveling along the cap engaging region **60**, a force measuring device, which could be a load cell, obtains measurements indicative of the torque exerted by the belts **54** and **56** onto the cap **32**. In general, this measurement indicative of the torque is a force reading, that can then be converted into a torque value using known formulas, such as $T=F*d$ (where F=the tangential force exerted by the belt on the cap, and d=the radius of the cap). Given that ideally the cap will not rotate significantly in light of the force being exerted on it by the belts, the force (F) could also be considered the resistance exerted on the belts **54** and **56** by the cap.

The length of the cap engaging region **60** can be selected such that the amount of torque that is applied to a cap while it travels through the cap engaging region **60** is not sufficient to cause the cap **32** to be tightened significantly further onto the container **30**. Instead, the length of the cap-engaging region **60** can be just long enough to obtain an accurate torque reading.

In addition, the driving mechanisms that control the driven pulleys **58***b* are such that they prevent the cap engaging belts **54** and **56** from applying more than a predetermined maximum amount of torque to the caps **32**. More specifically, the driven pulleys **58***b* are in communication with either mechanical or electrical arrangements for preventing the belts **54** and **56** from applying too much torque to the caps **32**. For example, a load cell, or other force measuring device, that is in communication with the driven pulleys **58***b* can obtain measurements of the force that is being applied to the caps by the belts **54** and **56**. As such, when it is detected that the force (or torque) that is being applied to the cap **32** has reached a predetermined maximum torque value, a signal can be issued to the controller (later called **76**) for causing the belts **54** and **56** to stop applying force to the caps **32**. For example, the driving mechanism that causes a force to be applied to the caps **32** can be controlled based on electrical signals from the controller, or the driving mechanism can include a mechanical or electrical clutch that slips when a predetermined force is applied to the caps **32**.

Therefore, regardless of how the drive mechanisms are controlled, the cap engaging belts **54** and **56** are generally configured such that they are unable to apply more than a predetermined maximum torque to the caps **32**. This predetermined maximum torque value will generally be set to an upper limit of an acceptable torque range to which caps **32** can be applied to their respective containers **30**. Above that predetermined maximum torque value, the caps **32** may be too difficult for an average person to remove from the containers.

Shown in FIG. **5** is a non-limiting functional block diagram of the torque measuring assembly **50**. As shown, the torque measuring assembly **50** includes a cap engaging assembly **72** and a torque reading assembly **74** that are in communication with each other, as well as a processing entity **76**. The processing entity **76** is in communication with a memory unit **70** that includes data **78** and program instructions **80**. Each of these components will be described in more detail below.

The cap engaging assembly **72** comprises the components necessary for engaging the caps **32** and for causing the caps **32** to spin in relation to the containers **34**. In the non-limiting embodiment of the invention shown in FIGS. **2** through **4**, the cap engaging assembly **72** comprises the pulleys **58***a* and **58***b*, and the cap engaging belts **54** and **56**. Although not shown in the Figures, the cap engaging assembly **72** can also include a drive mechanism that includes a motor and a gear box for causing the pulleys **58***a* and **58***b* to rotate. It should be appreciated that in alternative embodiments of the present invention, the cap engaging assembly **72** may not include the pulleys **58***a* and **58***b* and/or the belts **54** and **56** and instead, may include different components, such as rotating discs or wheels.

The torque reading assembly **74** comprises the necessary components for obtaining measurements indicative of the torque applied to the caps **32**. For example, the measurements may include a reading of the tangential force being applied to the caps **32** by the cap engaging assembly **72**, from which a torque measurement can be derived. In accordance with a non-limiting example of implementation, the torque reading assembly **74** includes a torque sensing device that is in communication with at least one of the driven pulleys **58***b*. The manner in which the torque sensing device is mounted to the driven pulleys **58***b* is known in the art, and as such will not be described in more detail herein. The torque sensing device is preferably an electronic device, such as an electronic load cell, that converts a force into an electrical signal. In most electronic load cells, the force is detected via one or more strain gauges and is then converted into an electrical signal. It should be appreciated that other types of load cells are also within the scope of the present invention, such as hydraulic load cells or piezo electric load cells. Once a reading of the force has been obtained, the torque measurement can be obtained using a simple formula: T=F*d (where F=the tangential force applied to the cap and d=the radius of the cap **32**). This torque measurement may be calculated by the load cell if the load cell includes processing capability, or alternatively, the torque measurement can be calculated by the processing entity **76** upon receipt of the force reading from the load cell. As such, in certain embodiments, the torque reading assembly **74** does not actually derive a torque measurement.

The processing entity **76** can include any type of processing unit (whether located locally or remotely) for obtaining readings from the torque reading assembly **74**. For example, the processing entity **76** may be embodied as an on-board computing unit that is dedicated to the container capping machine **10**. Alternatively, the processing entity **76** may be embodied as a PC, such as a desktop computer, a laptop, or a computer tablet, among other possibilities. The processing entity **76** may be located in proximity to the container capping machine **10**, and connected to the container capping machine **10** via wires and cables or via a wireless connection. Or alternatively, the processing entity **76** may be located remotely from the container capping machine **10** such that is in communication with the container capping machine **10** over a network such as an intranet or internet.

As mentioned above, the processing entity **76** is in communication with a memory unit **70** over a communication bus. The memory unit **70** includes data **78** and program instructions **80**. The processing unit **76** is adapted to process the data **78** and the program instructions **80** in order to implement the functionality described herein.

The manner in which the torque measuring assembly **50** operates will now be described in more detail with respect to the flow chart shown in FIG. **6**. It should be appreciated that the torque measuring assembly **50** is positioned following the cap applying station **14**, and as such receives containers **30** that have already had the caps **32** secured thereon. The torque measuring assembly **50** is positioned following the cap applying station **14** so as to ensure that the caps **32** have been screwed onto the containers **30** to at least a minimum required torque value.

Firstly, at step **100**, the torque measuring assembly **50**, and specifically the cap engaging assembly **72**, engages a screwed cap **32**. In the non-limiting embodiment shown in the Figures, it is the cap engaging belts **54** and **56** of the torque measuring assembly **50** that engage the cap **32**. At the same time, the container **30** on which the cap **32** has been screwed, is stabilized via the container gripping belts **22** and **24**. In this manner the container gripping belts **22** and **24** stabilize the container **30** as the container **30** and cap **32** travel through the torque measuring assembly **50**.

As shown in the block diagram of FIG. **5**, the processing entity **76** is in communication with the cap engaging assembly **72** (which includes the cap engaging belts **54** and **56**), such that the processing entity **76** can control the operation of the cap engaging belts **54** and **56**. More specifically, the processing entity **76** can control the operation of the motor (not shown) that drives the cap engaging belts **54** and **56**. For example, the processing entity **76** can cause the speed of the belts **54** and **56**, and in some cases, the amount of force that can be applied by the belts **54** and **56** onto the caps **32**, to be controlled.

At step **102**, a torque is applied to the caps **32**. Although step **102** is depicted following step **100**, in practice, a torque will be applied to the caps **32** as soon as the caps **32** are engaged by the belts **54** and **56**. As described above, when the cap engaging belts **54** and **56** engage a cap **32**, they apply a tangential force to the cap **32**, which causes a torque to be applied to the cap. It should be appreciated that the belts **54** and **56** feel an equivalent resistance exerted on them by the cap **32**.

At step **104**, the torque reading assembly **74** obtains a measurement indicative of the torque applied to the cap **32**. Given that the cap **32** has already (presumably) been screwed onto the container **30** via the cap screwing station **14**, the cap **32** that is engaged by the cap engaging belts **54** and **56** will apply a resistance against the rotation of the belts **54** and **56**. The amount of resistance applied against the cap engaging belts **54** and **56** will vary depending on how tightly the cap **32** has been screwed onto the container prior to being engaged by the cap engaging belts **54** and **56**. For example, in the case where the cap **32** has not been screwed onto the container very tightly, then the cap will apply a relatively low resistance against the belts **54** and **56**. In fact, the rotation of the belts **54** and **56** may cause the cap **32** to be further tightened. And conversely, in the case where the cap **32** has already been screwed onto the cap quite strongly, the cap **32** will apply a higher resistance against the belts **54** and **56**. A measurement of resistance (i.e. the force against the rotation of the belts **54** and **56**) will be obtained by the torque reading assembly **74** (which could include a load cell or other force reading apparatus) as the cap **32** is engaged by the cap engaging belts **54** and **56**. This measurement of resistance against the cap engaging belts **54** and **56** can be measured either continually, or intermittently, as the cap **32** travels through the cap-engaging region **60**.

Once the cap **32** has left the cap engaging region **60** of the torque measuring assembly **50**, the measurements indicative of the torque applied to the cap (which could include one or more measurements of force or torque) are used in order to determine whether the cap **32** has been screwed onto the container **30** to the minimum required torque value. This is generally done by taking the maximum resistance value that was obtained by the torque reading assembly **74** while the cap **32** was engaged within the cap engaging region **60**. In most cases, this will be the last value that is obtained before the cap **32** leaves the cap engaging region **60**.

In accordance with a first non-limiting example, the measurements that are obtained by the torque reading assembly **74** are sent from the torque reading assembly **74** to the processing entity **76**, in real time, as they are being obtained by the torque reading assembly **74**. In an alternative embodiment, the measurements from the torque reading assembly **74** are only sent to the processing entity **76** once the cap **32** has left the cap engaging region **60**. In this embodiment, the torque reading assembly **74**, or a memory unit associated with the torque reading assembly **74**, is able to store the values until the cap **32** has left the cap engaging region **60**. In yet a further embodiment, instead of providing a series of measurements of the force or torque values measured as the cap **32** moves through the torque measuring assembly **50**, the torque reading assembly **74** provides only a single measurement to the processing entity **76**. For example, only the final measurement or the highest measurement that is obtained by the torque reading assembly **74** is sent to the processing entity **76**.

The torque reading assembly **74** may convert the force/resistance readings obtained into torque values, such that it is the torque values that are supplied to the processing entity **76**. Alternatively, the torque reading assembly **74** may simply provide the force/resistance readings to the processing entity **76**, such that it is the processing entity **76** that converts the force/resistance readings into torque values. As described above, a measurement of the torque that has been applied to the cap **32** can be obtained using the following formula: $\tau=F*d$, where F=the tangential force reading applied to the cap (or otherwise put, the resistance felt by the belts **54**) and d=the radius of the cap **32**.

It should be appreciated that the measurement indicative of the torque that has been applied to the cap **32** may not necessarily be a measurement of the actual amount of torque that has been applied to the cap **32**. Instead, it may simply be a value of the torque that could be obtained by the torque reading assembly **74** while the cap **32** passes through the torque measuring station **16**. In reality, it is possible that more torque has been applied to the cap **32** than can be measured during the brief interval during which the cap **32** passes through the torque measuring station **16**.

Ideally, each cap **32** has been applied to its respective container **30** to within at least a minimum required torque value by the container applying station **14**. This minimum required torque value may be different depending on the type of cap and the contents of the containers. For example, in the case of containers that store pharmaceutical contents, it may be desirable that the cap is tightened onto the container to a greater level of torque than a container that stores non-pharmaceutical items. The cap engaging belts **54** and **56** are calibrated such that if the cap is tightened to the minimum required torque value, then the torque reading assembly **74** will obtain a reading that falls within a predetermined torque range. However, if the cap **32** has not been tightened to within the predetermined torque range, then the torque reading assembly **74** will obtain a reading that falls outside the predetermined torque range. In most cases, the minimum required torque value will be at the bottom end of the predetermined torque range.

The predetermined torque range can be stored within the data **78** of the memory unit **70**.

At step **106**, the container **30** is caused to be handled, once released from the cap engaging assembly **72**, on the basis of the one or more measurements of the torque obtained at step **104**. In accordance with a non-limiting embodiment, the container **30** is caused to be handled on the basis of whether or not one or more torque measurements obtained from the torque reading assembly **74** fall within the predetermined torque range. The predetermined torque range can include a minimum required torque value and a maximum required torque value, such that the range includes all torque values between that minimum and maximum required torque range. Or the predetermined torque range can simply be a minimum required torque value, such that any torque value that is above the minimum required torque value falls within the predetermined torque range.

The determination as to whether or not the one or more torque measurements obtained at step **104** falls within the predetermined acceptable torque range is performed by the processing entity **76**. In accordance with a non-limiting embodiment, this determination can be done via a simple comparison algorithm that compares one or more measured torque values with the predetermined torque range. This may be done by checking whether at least one of the measured torque values (such as the maximum torque value measured) is greater than or equal to a minimum required torque value, and less than or equal to a maximum allowed torque value.

In the case where the measured torque value falls within the predetermined torque range, the processing entity **76** may determine that the cap has been screwed onto the container to at least the minimum required torque value. However, in the case where the measured torque value falls outside the predetermined torque range, the processing entity **76** may determine that the cap **32** has either been screwed onto the container too loosely or too tightly.

In yet a further non-limiting example, the processing entity **76** may simply compare a measured torque value (such as the maximum torque value measured) to the predetermined torque range, by determining whether the measured torque value is greater than a predetermined minimum required torque value. As such, it should be appreciated that there are numerous algorithms that could be used by the processing entity **76** in order to determine whether a cap **32** has been screwed onto a container **30** to an acceptable torque level. The above described algorithms are presented for the sake of example only.

It should be appreciated that the processing entity **76** may use one or more of the measured torque values when performing this comparison algorithm. For example, the processing entity **76** may compare only the maximum torque value obtained by the torque reading assembly **74**. Or the processing unit **76** may consider an average of the torque values obtained by the torque reading assembly **74**. In yet a further alternative, a range of values could be used, such that the processing entity **76** considers a plurality of measured torque values when considering how to handle the containers **30**.

In the case where the cap **32** is determined to be screwed onto the container **30** to at least the minimum required torque level, the container **30** will be handled in a first way once it has been released from the torque measuring assembly **50**. For example, when the one or more measured torque values fall within the predetermined acceptable torque range, meaning that the cap **32** has been screwed onto the container **30** to an acceptable torque level, then the container may be handled such that it is allowed to continue towards the next packaging station (which my be to apply a label, or to package the container in a box to be shipped to a purchaser).

In contrast, in the case where it is determined that the cap **32** is not screwed onto the container **30** to at least the minimum required torque level, then the container **30** will be handled in a different way once it has been released from the torque measuring assembly **50**. For example, when a measured torque value falls outside the predetermined acceptable torque range, such that it is determined that the cap **32** has not been screwed onto the container **30** tightly enough or too tightly, then container **30** may be handled in one or more of the following ways:

- the container **30** may be rejected such that is removed from continuing along a production path for the containers;
- the container **30** may be caused to go through the cap applying station **14** again, such that the cap **32** can be further tightened;
- the container **30** can be identified to an operator of the container capping machine **10**, via a visual indicator on a screen or an audible indicator issued over one or more speakers, as being defective.

In accordance with a non-limiting embodiment, it is the processing entity **76** that causes the container **30** to be handled on the basis of the measured torque values that are obtained from the torque reading assembly **74**. For example, when the processing entity **76** determines that one or more measured torque values fall outside the predetermined acceptable torque range, then the processing entity **76** can issue a signal to a container rejection device for causing the container rejection device to remove the container **30** from the production line.

Shown in FIG. **7** is a non-limiting example of a rejection device **52**. The rejection device **52** includes the container gripping belt **22** and a set of pushing devices **60***a*, **60***b*, **60***c* and **60***d* that are operative for pushing defective bottles against the container gripping belt **22** such that the container gripping belt **22** can lead the defective containers away from continued travel along path **12**.

In the embodiment shown, container gripping belt **22** extends farther along the path **12** than container gripping belt **24**. In this manner, the end portion of the container gripping belt **22** can work in conjunction with the set of pushing devices **60***a*, **60***b*, **60***c* and **60***d* to remove defective containers from continued travel along the production path **12**. It should be appreciated that in an alternative embodiment, the container gripping belt **22** can be the same length as the container gripping belt **22**, and a separate container gripping belt can be positioned following the container gripping belt **22**. In this manner, the separate container gripping belt can work together with the pushing devices **60***a*, **60***b*, **60***c* and **60***d*, in order to act as a rejection device.

As shown, the pushing devices **60***a*, **60***b*, **60***c* and **60***d* are positioned on the opposite side of the path **12** from the container gripping belt **22**. The default position of the pushing devices **60***a*, **60***b*, **60***c* and **60***d* is such that they do not obstruct the travel of non-defective containers **30** along the path **12**. However, in operation, when the processing entity **76** has detected a defective container, a signal is issued to the pushing devices **60***a*, **60***b*, **60***c* and **60***d* of the rejection device **52**. The signal causes the pushing devices **60***a*, **60***b*, **60***c* and **60***d* to extend forward one-by-one in order to make contact with the defective container **30**. In accordance with a non-limiting embodiment, the pushing devices **60***a*, **60***b*, **60***c* and **60***d* are activated by pistons that cause the pushing devices to move forwards and backwards. The pushing devices **60***a*, **60***b*, **60***c* and **60***d* cause the defective container **30** to be pushed against the container gripping belt **22**. The shape of the pushing devices **60***a*, **60***b*, **60***c* and **60***d*, as well as their sequential movement creates an arcuate path for the defective container, such that the defective container curves around the pulley **25***b*, and is removed from continued travel along the path **12**. As such, the rejection device **52** creates an alternative "rejection" path that can be used to remove defective containers from continued travel along the production line **12**.

In the case where a container is determined by the torque measuring assembly **50** to be defective (meaning that the cap is too tight, too loose, misaligned, etc. . . .) then a signal can be sent to the rejection device **52** for causing the actuation of the pushing devices **60***a*, **60***b*, **60***c* and **60***d*, which push the defective container against the container gripping belt **22** for removing the defective container from continued travel along the production line. The defective containers may be lead to a disposal bin, or other container receptacle positioned behind the container capping machine **10**. In this manner, defective containers are automatically removed from continued travel along the production line when they are discovered to be defective.

Alternatively, the defective containers can be handled by causing them to be identified to an operator of the container capping machine **10**. For example, the processing entity **76** can cause an indication to be provided to an operator of the torque measuring assembly indicating that the container **30** is faulty, such that the operator can then chose how to handle the container.

For example, the processing entity **76** can be in communication with a display unit (not shown), such as a display screen, a printer, a personal digital assistant, etc. . . . As such, the operator of the torque measuring assembly **50** can receive the indication that a container is defective via a visual signal displayed on the display unit. Alternatively, the processing entity **76** can be in communication with a set of speakers, such that the operator can be provided with the indication of a defective container via an audible signal, such as a beeping or a siren. At that point the operator can remove the container, or send the container back to the cap applying station **14** for further processing.

It should be appreciated that during operation, the torque measuring assembly **50** receives a series of successive containers **30** onto which have been secured respective caps **32**. In accordance with a non-limiting example of implementation, as the series of containers **30** pass through the torque measuring assembly **50**, the processing entity **76** is operative for causing the measurements of the torque associated with subsequent caps **32** to be displayed on the display unit. In addition, in the case where the torque associated with a given cap **32** falls outside of the predetermined torque range, the processing entity **76** is operative for causing an indication that the cap **32** (or the associated container **30**) is defective to be displayed on the display unit. In this manner, an operator of the torque measuring assembly **50** can determine the best course of action for handling the defective container **30**.

As shown in FIG. **5**, the torque measuring assembly **50** includes a memory unit **70**. In accordance with a non-limiting example of implementation of the present invention, the one or more resistance measurements and/or torque measurements associated with subsequent caps **32** can be stored within the data **78** of the memory unit **70**. These resistance measurements and/or torque measurements can be used in order to generate statistics associated with the operation of the torque measuring assembly **50**. It should be appreciated that the statistics can include any type of information that can be generated on the basis of the resistance measurements/torque measurements.

For example, the statistics may include:

- a graph of the resistance/torque measurements for a single cap **32** as it travels through the cap engaging region **60** of the torque measuring assembly **50**. This graph may be displayed on a display unit such that an operator of the container capping machine **10** can view the forces that the cap **32** experiences as it travels through the cap engaging assembly **50**;
- an indication of the number or percentage of containers **30** that have been determined to be defective;
- an indication of the maximum torque value that has been measured for one or more of the caps **32** that have gone through the torque reading assembly **50**.

On the basis of these statistics, different parameters of the torque measuring assembly **50**, or the container capping machine **10** can be adjusted. For example, in the case where too many containers are being rejected because the caps **32** are not being applied tightly enough, modifications can be made to the cap applying assembly **14** such that more torque is applied to the caps **32**.

It should be appreciated that the torque measuring assembly **50** of the present invention can be integrally included within a capping machine **10**, as shown in FIGS. **2** and **3**, or alternatively, the torque measuring assembly **50** can be a stand-alone component that can be retrofitted into existing container capping machines, or that can be added as a separate station in many container filling production lines.

Alternative Embodiment

Shown in FIGS. **8** and **9** is a torque measuring station **110** in accordance with an alternative non-limiting embodiment of the present invention. As will be explained in more detail below, in this alternative embodiment, the torque measuring station **110** is operative for applying a torque to the cap **32** in a direction tending to unscrew the cap **32** from the container **30**.

As shown in FIGS. **8** and **9**, the torque measuring station **110** includes a torque measuring assembly **108** that comprises a pair of container gripping belts **113** and a pair of cap engaging belts **111** and **112**. Although container gripping belts **113** are shown in FIGS. **8** and **9**, in an alternative embodiment, the container gripping belts **22** and **24** that are common with the cap applying station **14** could be used. The two container gripping belts **113** are shown positioned opposite each other at a predetermined distance which can be adjusted so as to be able to accommodate containers **30** of different shapes and/or sizes.

In addition, the cap engaging belts **111** and **112** are also shown positioned opposite each other, with a predetermined distance therebetween. The distance separating the cap engaging belts **111** and **112** can be adjusted so as to be able to accommodate caps **32** of different shapes and/or sizes. The position of the cap engaging belts **111** and **112** can be adjusted independently of the position of the container gripping belts **113**. As such the belts **111**, **112** and **113** can be moved closer together or farther apart depending on the size of the containers **30** and caps **32** being handled.

Each of the two container engaging belts **113** is positioned around a pair of pulleys **116***a* and **116***b*. At least one of the pulleys **116***a* and **116***b* is driven by a motor (not shown) for causing the belts **113** to rotate. For the purposes of the present description, the pulleys **116***b* will be described as being the driven pulleys, however, it should be appreciated that the pulleys **116***a* (or both the pulleys **116***a* and **116***b*) could be the driven pulleys. During operation, the pulleys **116***b* cause the belts **113** to rotate. More specifically, the two belts **113** are caused to rotate at substantially the same speed, with one belt moving in a counter clock-wise direction, and the other belt moving in a clock-wise direction, such that the rotation of the two belts **113** does not cause the container **30** to spin while it is being gripped by the belts **113**. As best shown in FIG. **9**, the container gripping belts **113** are provided for stabilizing and supporting the containers **30** as they travel through the torque measuring assembly **108**.

The pair of cap engaging belts **111** and **112** are each positioned around two pulleys **114***a* and **114***b*. At least one of these pulleys **114***a* and **114***b* is driven by a motor (not shown) for causing the belts **111** and **112** to rotate. For the purposes of the present description, the pulleys **114***b* will be described as being the driven pulleys, however, it should be appreciated that the pulleys **114***a* (or both the pulleys **114***a* and **114***b*) could be the driven pulleys. During operation, the pulleys **114***b* cause the belts **111** and **112** to rotate. More specifically, both belts **111** and **112** are caused to rotate in a clockwise direction, such that a tangential force is applied to the caps **32**. This tangential force is applied to the caps **32** in a direction tending to unscrew the caps **32**.

The torque measuring assembly **108** in accordance with the alternative embodiment shown in FIGS. **8** and **9** includes the same functional components, as the torque measuring assembly **50** shown in FIG. **5**, namely a torque reading assembly **74**, a processing unit **76** and a memory **70** as described with respect to FIG. **5**.

The tangential force that is applied to a cap **32** by the cap engaging belts **111** and **112** is such that it is slightly lower than required for causing the cap to be unscrewed, assuming the cap **32** was properly applied to the container **30**. More specifically, the force that is applied to a cap **32** by the cap engaging belts **111** and **112** is such that if the cap **32** was screwed onto the container **30** to the minimum required torque value, then the cap engaging belts **111** and **112** will not apply enough force to unscrew the cap **32** from the container **30**. Instead, the cap **32** will apply a resistive force against the cap engaging belts **111** and **112**, which can be measured by the torque reading assembly **74**.

However, if the caps **32** have not been screwed onto the containers **30** to the minimum required torque value, then the force that is applied by the cap engaging belts **111** and **112** will be sufficient to cause the cap **32** to unscrew from the container **30**. In such a case, the cap **32** will not apply much of a resistive force against the belts **111** and **112** at all.

Each of the cap-engaging belts **111** and **112** includes a cap engaging region **115** that is the region that engages the caps **32**. In the same manner as described with respect to FIG. **5**, the torque reading assembly **74** includes a load cell or other force reading mechanism known in the art, that is in communication with the driven pulleys **114***b* of the cap engaging belts **111** for measuring the resistance applied against the belts **111** and **112** by the caps **32**. As mentioned above, the purpose of the cap engaging belts **111** and **112** of the torque measuring assembly **108** is to cause a force to be applied to the caps **32**, such that a measurement can be taken to determine whether the cap **32** has been screwed onto the container to a minimum required torque value. In operation, as a cap **32** is engaged by the belts **111** and **112**, the belts **111** and **112** exert a tangential force against the cap **32** in a direction tending to unscrew the cap. Given that the cap **32** has already been screwed onto the container **30**, to presumably a minimum torque level, the cap **32** will apply a resistance against the rotation of the belts **111** and **112**. While the cap **32** is traveling along the cap engaging region **115**, the torque reading assembly **74** obtains measurements of the resistance exerted by the cap **32** onto the belts **111** and **112**.

If the resistive force applied against the belts **111** and **112** by the cap **32** reaches a certain predetermined level, then it can be assumed that the cap **32** has been screwed onto the container **30** to an acceptable minimum torque value. However, in the case where there is very little resistive force exerted against the belts **111** and **112**, or the resistive force suddenly drops, then it means that the tangential force that has been applied to the cap engaging belts **111** and **112** by the cap **32** was not sufficient enough, and the cap **32** became unscrewed. In such a case, it can be assumed that the cap **32** was not screwed onto the container **30** tightly enough.

The driving mechanism that controls the driven pulleys **114***b* controls the force that the cap engaging belts **111** and **112** apply to the caps, such that the force is slightly lower than the force required to unscrew the caps **32** if the caps **32** were screwed onto the containers **30** to the minimum required torque value. More specifically, the driven pulleys **114***b* are in communication with either mechanical or electrical arrangements for controlling and/or limiting the force that is applied by the cap **32** to the engaging belts **111** and **112**. The force that is applied should be slightly lower than the force required to unscrew the caps **32** if they were screwed onto the containers **30** to the minimum required torque value, but the force would be less if the caps **32** were not screwed onto the containers to the minimum required torque value, since the caps **32** would become unscrewed and not apply any resistance to the belts **111** and **112**.

The cap engaging belts **111** and **112** are able to apply a predetermined force value that is slightly lower then the minimum required torque value to which the caps **32** should have been applied to the containers **30**. In accordance with a first non-limiting example, the driven pulleys **114***b* are in communication with a sensing device that is in communication with an electrical or mechanical clutch, such that once the predetermined force value has been achieved, the clutch slips such that the belts **111** and **112** no longer apply any force to the caps **32**. In an alternative arrangement, the torque reading assembly **74** that is operative for obtaining measurements of the resistive force exerted on the belts **111** and **112** can detect when the predetermined force value has been met, and can issue a signal to a processing unit (or other controller) for causing the belts **111** to cease applying a tangential force to the caps **32**. In either case, if the resistance applied by the caps **32** onto the cap engaging belts **111** and **112** reaches this predetermined force value, then the belts **111** and **112** cease to apply any further force, and the cap **32** is considered to be secured to the container **30** to the minimum required torque value.

Whereas, in the case where the predetermined force value that should be applied against the cap engaging belts **111** and **112** by the cap **32** is not met, or in the case where the predetermined force value is met, followed by a sharp decrease in resistance felt by the belts **111** and **112**, it will be assumed that the cap has become unscrewed, and as such does not meet the minimum required torque value.

The torque measuring assembly **108** in accordance with this alternative example of implementation operates in accordance with the method described with respect to FIG. **9**. At step **120**, a cap **32** is engaged by the cap engaging assembly **74**, which in the case of the torque measuring assembly **108** means that the cap **32** is engaged by the cap engaging belts **111** and **112**. At the same time, the container **30** on which the cap **32** has been screwed is engaged by the container gripping belts **113**.

At step **122**, a force is applied to the cap **32** by the cap engaging belts **111** and **112** in a direction tending to over torque the cap **32** from the container **30**. Then, at step **104**, the torque reading assembly **74** obtains a reading of the resistance applied against the cap engaging belts **111** and **112** by the cap **32**. A measurement of resistance (i.e. the force against the rotation of the belts **111** and **112**) will be obtained by a load cell, or other force reading device, as the cap **32** is engaged by the cap engaging belts **111** and **112**. Given that the cap **32** has already (presumably) been screwed onto the container **30** to a minimum required torque value, the cap **32** that is engaged by the cap engaging belts **111** and **112** will apply a resistance against the rotation of the belts **111** and **112**. So long as there is a resistance against the rotation of the belts **111** and **112**, the torque reading assembly **74** will obtain measurements of the resistive force applied. On the basis of these measurements, the processing entity **76** will determine that the belts **111** and **112** are not applying enough torque to cause the cap **32** to unscrew, and that accordingly, the cap **32** has been screwed onto the container sufficiently tightly.

However, in the case where the torque reading assembly **74** does not detect a resistance against the rotation of the cap engaging belts **111** and **112**, or detects a resistance that does not approach the predetermined force value, the processing entity **76** will determine that the cap **32** has not been screwed onto the container **30** to the required minimum torque value. As such, in the case of an absence, or significant decrease in the resistance applied against the cap engaging belts **111** and **112**, the container on which the cap **32** was screwed will be considered defective. This measurement of resistance against the cap engaging belts **111** and **112** can be measured either continually, or intermittently, as the cap **32** travels through the cap-engaging region **115**.

The determination as to whether or not the cap **32** has been secured to the container to the minimum required torque value is performed by the processing entity **76**. In accordance with a first embodiment, this determination is performed on the basis of the measurements received from the torque reading assembly **74**. The determination may be performed by comparing one or more of the measurements received from the torque reading assembly **74** against the predetermined force value. If the one or more measurements is close to or reaches the predetermined force value, then the processing entity **76** will determine that the cap **32** has been secured onto the container to the minimum required torque value. The processing entity **76** may also analyze the change in resistance values as the cap **32** travels through the cap engaging region **115**. For example, in the case where the cap **32** applied a strong resistance against the belts **111** and **112** at the beginning of the cap engaging region **115**, and then suddenly the resistance applied to the belts **111** and **112** decreased dramatically, the processing entity **76** may also determine that the cap **32** became unscrewed while it was in the cap engaging region **115**.

Alternatively, in accordance with a second non-limiting embodiment, the processing entity **76** may not even receive an actual force measurement from the torque reading assembly **74**. Instead, the torque reading assembly **74** may simply provide the processing entity **76** with an indication as to whether or not the predetermined force value was achieved. In such a case, based on the indication from the torque measuring assembly, the processing entity **76** will determine whether the cap **32** has been sufficiently tightened onto the container.

It should be appreciated that the measurements of resistance that are obtained by the torque reading assembly **74** can be transferred to the processing entity **76** in real time, as they are being obtained by the torque reading assembly **74** or they can be sent to the processing entity **76** only periodically, or once the cap **32** has left the cap engaging region **115**.

It should be appreciated that in this alternative embodiment, the torque measuring assembly **108** does not actually obtain a measurement of the torque that has been applied to the cap **32**. Instead, the torque measuring assembly **108** simply obtains an indication as to whether or not a cap **32** has been torqued to above a predetermined minimum required torque value. The cap engaging belts **111** and **112** are calibrated such that if the cap **32** is tightened to below a predetermined torque range specified for that container, then the torque reading assembly **108** will cause the cap **32** to become unscrewed from the container **30**, such that the container **30** and cap **32** are defective.

At step **106**, the container **30** is caused to be handled, once released from the cap engaging assembly **72**, on the basis of whether or not the cap **32** was determined to be defective.

As indicated above, this determination as to whether or not the cap is defective can be performed by the processing entity **76**. More specifically, once the processing entity **76** has received the resistance values that have been obtained from the torque reading assembly **74**, the processing entity **76** can determine from one or more of these values whether the cap **32** was unscrewed. For example, in the case where the torque reading assembly **74** initially measured a relatively high resistance against the cap engaging belts **111** and **112**, and then the resistance dropped significantly, it can be assumed that the resistance drop is due to the fact that the cap was too loose and became unscrewed. Alternatively, in the case where the processing entity **76** received only one resistance measurement from the torque reading assembly **74** (namely the measurement that was taken just before the cap **32** left the cap engaging region **115**) then that resistance value can be compared against a predetermined force value. In the case where the measured resistance value is less than the predetermined force value it can be determined that the cap was defective, or that the cap **32** was not screwed onto the container tightly enough.

In the case where it is determined that the cap **32** was not unscrewed, such that the level of torque to which the cap has been applied to the container is sufficient, then the container will be handled in a first manner once it has been released from the cap engaging assembly **72**. For example, the container may be handled by simply letting it continue towards the next packaging station within the production line (which may be a labeling station, or a final boxing station).

In contrast, in the case where it is determined that the cap is too loose, or has been unscrewed in the torque measuring station **115**, then the container will be handled in a different manner once it has been released from the cap engaging assembly **72**. For example, the container may be caused to be rejected. In such a scenario, the container **30** will be removed from continuing along a production path for the containers. In an alternative example, when the cap **32** has not been screwed onto the container **30** tightly enough, the container may be caused to go through the cap screwing station **14** again, such that the cap **32** can be further tightened.

In accordance with a non-limiting embodiment, it is the processing entity **76** that causes the container **32** to be handled on the basis of the measurements received from the torque measuring assembly **108**. For example, when the processing entity **76** determines that the cap has been unscrewed by the torque measuring station **110**, then the processing entity **76** can issue a signal to a container rejection device for causing the container rejection device to remove the container from the production line. Alternatively, the processing entity **76** can issue a signal to an operator of the torque measuring assembly, via a display screen, for example, such that the operator can ensure that the container **30** and the cap **32** are handled in an appropriate way.

The manners in which the defective containers can be handled is described in more detail above with respect to the torque measuring assembly **50**.

Although the present invention has been described in considerable detail with reference to certain preferred embodiments thereof, variations and refinements are possible without departing from the spirit of the invention. Therefore, the scope of the invention should be limited only by the appended claims and their equivalents.

What is claimed is:

1. A torque measuring station, comprising:

a) a cap-engaging assembly for engaging a cap that has been secured onto a container, the cap engaging assembly engaging the cap in a direction tending to screw the cap onto the container;

b) a torque reading assembly for obtaining a measurement from the cap-engaging assembly indicative of an application torque applied to the cap;

c) a processing entity in communication with said torque reading assembly for receiving said measurement indicative of the application torque, said processing entity causing the container to be handled, once released from said cap-engaging assembly, on the basis of said measurement indicative of the application torque applied to the cap.

2. A torque measuring station as defined in claim **1**, wherein said processing entity is operative for determining whether said measurement indicative of the application torque, falls within a predetermined range, said container being handled, once released from said cap-engaging assembly, on the basis of whether said measurement indicative of the application torque falls within the predetermined range.

3. A torque measuring station as defined in claim **2**, wherein said processing entity is operative for causing the container to be rejected when said measurement indicative of the application torque falls outside said predetermined range.

4. A torque measuring station as defined in claim **2**, wherein said processing entity is in communication with a display unit, said processing entity being operative for causing said measurement indicative of the application torque to be displayed on said display unit.

5. A torque measuring station as defined in claim **4**, wherein upon determination that said measurement indicative of the application torque falls outside of the predetermined range, said processing entity causing an indication that the container is defective to be displayed on the display unit.

6. A torque measuring station as defined in claim **1**, wherein said cap-engaging assembly includes at least one belt.

7. A torque measuring station as defined in claim **1**, wherein said torque reading assembly includes at least one torque sensing device.

8. A torque measuring station as defined in claim **1**, wherein said processing entity is operative for storing in a memory unit measurements indicative of the application torque applied to caps of different containers.

9. A torque measuring station as defined in claim **8**, wherein said processing entity is operative for generating statistics derived from said measurements indicative of the application torque applied to said caps of different containers.

10. A method, comprising:

a) engaging, at a cap-engaging assembly, a cap that has been secured onto a container in a direction tending to screw the cap onto the container;

b) obtaining a measurement indicative of an application torque applied to the cap;

c) causing the container to be handled, once released from the cap-engaging assembly, on the basis of the measurement indicative of the application torque applied to the cap.

11. A method as defined in claim **10**, further comprising determining, at least in part on the basis of said measurement indicative of the application torque applied to the cap, whether said measurement indicative of the application torque falls within a predetermined range.

12. A method as defined in claim **11**, further comprising causing the container to be handled, once released from said cap-engaging assembly, on the basis of whether said measurement indicative of the application torque falls within the predetermined range.

13. A method as defined in claim **12**, further comprising causing the container to be rejected, once released from said cap-engaging assembly, when said measurement indicative of the application torque falls outside said predetermined range.

14. A method as defined in claim **10**, wherein the cap-engaging assembly includes at least one belt.

15. A method as defined in claim **10**, wherein the measurement indicative of the application torque applied to the cap is obtained from at least one torque sensing device.

16. A method as defined in claim **15**, further comprising causing said measurement indicative of the application torque applied to the cap to be displayed on a display unit.

17. A method as defined in claim **10**, wherein said measurement indicative of the application torque applied to the cap is stored in a memory unit.

18. A method as defined in claim **10**, further comprising generating statistics derived from a plurality of measurements indicative of the application torque applied to subsequently engaged caps.

19. A torque measuring station, comprising:

a) a cap-engaging assembly for sequentially engaging caps that have been secured onto respective containers in a direction tending to screw the caps onto the containers;

b) a torque reading assembly operative for obtaining measurements indicative of the application torque applied to each of the sequentially engaged caps from said cap engaging assembly;

c) a processing entity in communication with said torque reading assembly for receiving the measurements indicative of the application torque applied to each of the sequentially engaged caps, said processing entity being operative for generating statistical data at least in part on the basis of the measurements indicative of the application torque applied to each of the sequentially engaged caps.

20. A torque measuring station as defined in claim **19**, wherein said processing entity is further operative for determining, at least in part on the basis of the measurements indicative of the application torque applied to each of the sequentially engaged caps, whether each measurement falls within a predetermined range.

21. A torque measuring station as defined in claim **20**, wherein said processing entity is further operative for causing a respective container to be handled, once it has been released from the cap-engaging assembly, on the basis of whether the measurement indicative of the application torque applied to a cap of the respective container falls within the predetermined range.

22. A torque measuring station as defined in claim **21**, wherein said processing entity is operative for causing the container to be rejected when the measurement indicative of the application torque applied to the cap falls outside the predetermined range.

23. A torque measuring station as defined in claim **20**, wherein the statistical data is representative of a number of caps whose caps have applied to respective containers to within a predetermined torque range.

24. A torque measuring station as defined in claim **20**, wherein the statistical data is representative of a plurality of measurements obtained by the torque reading assembly.

25. A container capping system, comprising:

a) a cap applying station operative for engaging a cap positioned on a container, said cap applying station being operative for applying an application torque to the cap for securing the cap onto the container;

b) a torque measuring station located subsequent to said cap applying station, said torque measuring station being operative for engaging the cap in a direction tending to screw the cap onto the container, said torque measuring station being operative for determining whether the application torque applied to the cap has reached a predetermined torque value.

26. A container capping system as defined in claim **25**, wherein the torque measuring station comprises a torque limiting device for limiting the torque applied to the cap when rotating the cap in a direction tending to screw the cap onto the container.

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